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United States Patent **4,455,790**
Curle **June 26, 1984**

Tarpaulin anchoring system

Abstract

A tarpaulin anchoring system for retaining a tarpaulin on a pile of stored grain or other granular material comprises a plurality of anchors embedded in the pile. Each anchor has an attachment element protruding upwardly from the pile, with the attachment element being connected to a fastener affixed to the underside of the tarpaulin. The anchors are placed in the grain pile, throughout the area covered by the tarpaulin, as required to retain it in place. The anchors themselves may be of a screw or auger type which can be driven into an existing grain pile and attached to a tarpaulin as it is spread over the pile. In the case where a tarp is suspended above a grain storage area prior to formation of the grain pile, the anchors may be discs or plates attached to the underside of the tarpaulin by ropes; the anchors are buried in the pile when formed.

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Claims

I claim:

1. An anchoring system for securing a tarpaulin or like ***flexible cover*** in covering relation on a pile of grain or other granular material, comprising a plurality of anchors each embedded at a substantial depth in the grain pile, the anchors being spaced throughout the area covered by the tarpaulin, each anchor having an attachment element extending upwardly from the top of the pile, and a plurality of fasteners affixed to the underside of the tarpaulin, each fastener being connected to an attachment element of one of the anchors to secure the tarpaulin in place, each anchor being held in position in the pile by the weight of the granular material above the anchor.

2. The tarpaulin anchoring system of claim 1 in which each anchor comprises a shaft, the attachment element being mounted on one end of the shaft, the anchor further comprising at least one flight of a spiral blade attached to the shaft adjacent the other end.

3. The tarpaulin anchoring system of claim 1 or 2 further comprising auxiliary means for holding down the edges of the tarpaulin.

4. The tarpaulin anchoring system of claim 1, further comprising a center leg which supports the tarpaulin prior to formation of the pile of granular material, in which the attachment element of each anchor comprises a flexible line hanging from a fastener on the tarpaulin, and a disc attached to the lower end of the line such that upon formation of the pile the disc is buried in the granular material.

5. The tarpaulin anchoring system of claim 4, further comprising stay lines connecting the discs to the floor on which the pile of granular material is formed to prevent displacement of the anchor during formation of the pile.

Description

BACKGROUND OF THE INVENTION

This invention relates to grain storage and aeration systems. Such systems are now being built which comprise relatively short sidewalls, enclosing a grain storage area either on the ground or a paved slab.

Grain is then stored in this structure in a pile. The pile is covered by a weatherproof tarpaulin to protect it from the elements. In some instances the grain storage pile may simply be formed on a suitable surface area with no side walls provided. Similar arrangements are used for storage of other granular materials, including sand, fertilizers, rock salt, and others.

In the past a tarpaulin or like ***flexible cover*** has been anchored on a grain pile by a variety of techniques. These included nailing the tarp edges to a wooden nailing strip, lashing the tarpaulin down with a network of cables or ropes, and placing ***weights*** such as old tires on top of the tarpaulin. The tires themselves are sometimes connected together with a network of ropes, wires, or cables. Some of these methods are fairly effective, but they require a great deal of materials and labor to cover and uncover the grain pile.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an anchoring system for a tarpaulin cover for a pile of grain or other granular material which is economically constructed and simple and effective in use.

Another object is to provide a tarpaulin anchoring system which can be put in place either before or after a grain pile has been formed.

Another object is to provide a tarpaulin anchoring system which will work equally well with a pre-fabricated tarpaulin or a tarp that is assembled on top of the grain pile.

Accordingly, the invention is directed to an anchoring system for securing a tarpaulin or like ***flexible cover*** in covering relation on a pile of grain or other granular material. The system includes a plurality of anchors, each embedded at a substantial depth in the grain pile. Each anchor has an attachment element extending upwardly from the top of the pile. A plurality of fasteners are affixed to the underside of the tarpaulin and each fastener is connected to an attachment element of one of the anchors to secure the tarpaulin in place. Each anchor is held in position in the pile by the weight of the granular material above the anchor.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a grain storage structure incorporating a tarpaulin anchoring system in accordance with one embodiment of the invention.

FIG. 2 is a schematic sectional elevation view of the grain storage structure of FIG. 1, taken approximately as indicated by line 2--2 of FIG. 1.

FIG. 3 is an enlarged detail section view taken approximately along line 3--3 of FIG. 1.

FIG. 4 is an elevation view, on an enlarged scale, of an anchor according to another embodiment of the invention.

FIG. 5 is a schematic sectional elevation view of a grain storage structure having a tarp supported by a central leg and incorporating a further embodiment of the anchoring system of the present invention.

FIG. 6 is an enlarged detail view showing an anchor used in the system of FIG. 5.

DESCRIPTION OF A PREFERRED EMBODIMENT

A grain storage and aeration system 10 for protecting a mass of stored grain or other granular commodity is generally illustrated in FIGS. 1 and 2. The storage system 10 includes a floor 12 (FIG. 2) which is preferably paved with asphalt or concrete; however, the floor 12 could simply be bare, packed earth. A series of support trusses 14 are mounted at spaced locations around the periphery of the floor 12. Perforated sheet metal sidewalls 16 are supported on the trusses 14. The sidewalls enclose a grain storage area on the floor 12 which accommodates a mass of stored grain or other granular commodity. The sidewall support trusses 14 are anchored to a concrete pad 18 which extends around the periphery of the grain storage area. While FIG. 1 illustrates a rectangular storage system 10, it should be understood that other shapes may be used.

FIG. 2 illustrates a forced aeration system which provides airflow through a grain mass 26 stored in the system 10. A first set of perforated aeration ducts 20 extend across the floor 12. These ducts extend through the sidewalls 16 and are connected to exhaust fans (not shown) outside of the sidewalls. After the storage system 10 has been filled with grain, a set of light-weight perforated plastic aeration ducts 22 is laid across the top of the grain. These upper aeration ducts extend slightly beyond the upper edges of the sidewalls 16 (see FIG. 1) so that the ends of the ducts are exposed to air outside of the storage structure.

After the upper aeration ducts 22 are put in place, a heavy-duty, flexible weatherproof cover, such as a tarpaulin 24, is installed over the top of the grain and over the upper aeration ducts 22. Once the tarpaulin is securely in place, the exhaust fans may be turned on. Air is then pulled in through the perforated sidewalls 16 and the upper aeration ducts 22. The air moves downwardly through the grain under the tarp and out through the ducts 20 to aerate the entire grain mass. Further details of the grain storage system 10 and its aeration system are shown and described in the co-pending application of John Aldag, Ser. No. 353,184, filed on Mar. 1, 1982.

The grain pile 26 is shown in FIGS. 2 and 3. A plurality of anchors 28 embedded in the grain pile 26 hold the tarpaulin 24 in place. The anchors 28 are placed in the grain pile throughout the area covered by the tarpaulin 24, as required to retain it. In the preferred arrangement shown in FIG. 1, the anchors 28 are located at intervals along the seams of the tarpaulin. The tarpaulin may be brought to the storage site in sections which are then laced together as they are spread on the completed grain pile. The seams of the tarp sections are shown at 30. The anchors 28 are driven into the grain pile along the locations of the seams. As each seam is laced together the tarp is connected to the anchors, either by separate fastening means or by lacing the anchor into the seam itself.

Details of a seam and an anchor are shown in FIG. 3. Each anchor 28 has an attachment element which protrudes from the grain pile 26. As shown, the attachment element comprises a ring 32 attached to the top of a shaft 34. A spiral blade 36 is attached to the shaft 34. Thus, the anchor 28 is essentially in the form of an auger. The spiral blade 36 preferably extends to the lower end of the shaft 34 so that when the anchor is embedded in the grain pile 26 the maximum weight of grain will bear on the spiral blade 36. It may be most economical to use standard, off-the-shelf conveyor augers as the anchors 28, with an attachment ring mounted on one end of each auger shaft. Also in this regard, the attachment element 32 may have a form other than the ring shown. For example, it could be a hook with a spring-loaded retainer.

FIG. 4 shows an alternate form 28A of the auger-type anchor. Here there is only one flight 36A of the spiral blade. It is located at the bottom of shaft 34.

The attachment elements on the anchors cooperate with a plurality of fasteners affixed to the underside of the tarpaulin 24. FIG. 3 illustrates a typical fastener. The seam 30 of the tarpaulin includes layers 38A and

38B which are laced together by cord 40. A tie-down strap 42 is stitched at one end 44 to the underside of the tarpaulin layer 38B. A buckle 46 is also stitched into the underside of the tarpaulin. When it is desired to attach the tarpaulin to an anchor 28 (the anchor first having been screwed into the grain pile) the strap 42 is threaded through the attachment element 32 of the anchor 28 and then the strap is threaded into the buckle 46 so that the strap 42 forms a closed loop on the underside of the tarpaulin.

It will be understood that other arrangements could be used for fastening the tarpaulin to the anchors. For example, the tie-down strap 42 could be formed in two pieces, each sewn to the tarp, with an intermediate buckle connecting the two pieces after they are threaded through the anchors. Or the fasteners and attachment combination could be a hook and eye arrangement, perhaps with a spring-loaded retainer. In any event, the anchors are embedded in the grain and the tarpaulin is attached to the anchors at the time of placing the tarp on the grain pile.

Removal of the tarpaulin and anchors from the grain storage system 10 is simple and expedient. The tarp seams 30 are unlaced and the straps 42 are unbuckled or otherwise released to separate the tarpaulin from the anchors 28. The anchors 28 are readily removed by simply unscrewing them from the grain pile 26. Thus, both the tarpaulin 24 and the anchors 28 are rapidly and conveniently removable from the grain pile.

The tarpaulin anchoring technique described in connection with FIGS. 1-4 is not confined to use with a sidewall structure and aeration apparatus as incorporated in the complete storage system 10. Rather, it can be applied to virtually any tarpaulin as spread over or assembled on a previously formed pile of grain or other granular material of any desired configuration. In some instances it may be desirable to supplement the auger anchors 28 with spaced tie down loops or the like around the periphery of the tarpaulin 24 to limit the entry of air beneath the tarp for strong wind conditions. Any desired form of supplemental peripheral tie down arrangement can be employed. For an unwalled grain pile on an earth base, simple loops and stakes will do.

The anchors 28 afford appreciable advantages as compared with conventional tarpaulin anchoring techniques.

There is no external cabling, ***weights,*** or other apparatus to be dragged across the tarpaulin or that could shift on the tarp surface in adverse weather, with possible resultant damage to the tarpaulin. The anchors hold the tarp 24 firmly against the surface of the grain pile even under extreme windy conditions; the anchors 28 cannot be moved by the wind because they are not exposed to it. The auger anchors are quickly inserted and equally quickly removed from the grain pile by simply screwing them in or out. Nevertheless, they provide firm anchorage, capable of withstanding high winds and other adverse weather conditions.

The anchoring system of FIGS. 1-4 is primarily suitable for use when a tarpaulin is applied to a completed grain pile. There are instances, however, where it is desirable to place the tarp over a grain storage structure prior to filling it. In such "tarp-first" systems, an alternate arrangement for the anchoring system is required. This arrangement is shown in FIGS. 5 and 6. The grain storage system has many of the same components as the system described above. There is a floor 12, support trusses 14, and sidewalls 16. Aeration ducts, though not shown in FIG. 5, may be provided.

In addition to these common parts, the "tarp-first" system has a center leg 48. The center leg is a hollow post having a series of large openings 50 therein. Grain is fed through a conveyor 52 to the top of the center leg 48. From there it moves down through the center leg and out the openings 50 of leg 48 to fill

the grain storage area. The tarpaulin 24A is supported at the center by the leg 48. The edges of the tarpaulin are fastened to the sidewalls 16.

Since the tarp 24A is raised on the center leg 48 before the grain pile is formed, it is not usually practical to reopen the tarp to install the auger-type anchors 28 after the grain pile is formed. Instead, this embodiment of the invention provides for placement of an alternate type of anchor prior to formation of the grain pile. These anchors 54 are spaced throughout the area of the tarp. Each anchor 54 includes a flexible cable or rope 56 having one end secured to a fastener 57 on the underside of the tarpaulin 24. In a preferred embodiment the member 56 is made of nylon rope. A flat disc 58 is attached to the lower end of the line by suitable means. The disc 58 can be made of rigid plastic or wood or other lightweight material. A stay line 60 is connected from each disc 58 to the floor 12. Light twine can be used for the stay lines. The purpose of the stay lines is to prevent the anchors 54 from being displaced during filling of the grain storage area. When the grain storage area is filled the anchors 54 are embedded in the grain with sufficient weight of grain above the discs 58 to hold them in place, thereby securing the tarpaulin by means of the lines 56.

By calculating the volume of the commodity resting on a disc (or on the lowest flight of an auger) and multiplying by the density of the commodity, one can determine the anchoring capability of the commodity. By way of example, if corn is being stored, an eight inch diameter disc 58 on a six foot long line 56 is effectively anchored by approximately 94 pounds of corn. A ten inch disc on a four foot line is anchored by about 98 pounds of corn. A twelve inch disc on a four foot line is anchored by some 141 pounds of corn.

While preferred forms of the invention have been shown and described, it will be understood that modifications of the anchoring systems shown can be made. For example, it would be possible to have auger-type anchors attached to the tarp with their shafts accessible for rotation from the outside of the tarp. This would require a sealable opening in the tarp. And in such a case it may be preferable to have a flight of a spiral blade that moves up and down on a rotating shaft while the shaft itself remains stationary in a vertical direction. Such an arrangement would be suitable for use in a system where grain is frequently added to or taken away from the storage structure, since the augers could readily be engaged and disengaged from the grain pile.

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United States Patent **5,176,421**
Fasiska **January 5, 1993**

Automobile cover system

Abstract

A cover system for an automobile includes a ***flexible cover,*** preferably of nylon, having leading, trailing and side edge portions and of a suitable dimension to fit over the entire car body from the rear bumper to the front bumper and sides thereof. The ***flexible cover*** includes an elastic leader segment attached at a first end to the cover and spaced from the trailing edge thereof. A second end of the leader segment is attached to a rotatable spool housed in a containment tube. The spool is rotated for storing in the cover by a motor, by a spring-biased shaft arrangement or by a manually turnable crank, or combinations thereof. The containment tube may be pivotally mounted by straps within the interior of the trunk for storage therein and is adapted to be pivotally swung outwardly from the trunk to an operable position at the rear of the trunk lid. After the cover is applied to the automobile, the containment tube is swung back to the trunk compartment for safe storage.

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Parent Case Text

CROSS REFERENCE TO RELATED APPLICATIONS

This is a continuation-in-part application of my co-pending U.S. patent application Ser. No. 07/261,037,

filed Nov. 16, 1988, now abandoned, entitled: "Vehicle Cover System", which, in turn, is a continuation-in-part application of U.S. patent application Ser. No. 07/106,816, filed Oct. 13, 1987, entitled: "Remote Control Power-Assisted Vehicle Cover", now U.S. Pat. No. 4,848,823.

Claims

What is claimed is:

1. A cover system for an automobile comprising:

(a) a ***flexible cover*** means having a leading edge and a spaced trailing edge defining a length therebetween and opposed side edges, said cover means of a size suitable for covering the automobile from a rear bumper to a front bumper and around the sides thereof; said cover means including a leader segment having first and second ends attached along its first end to the cover means defining an attachment area positioned substantially mid-way between said side edges and spaced from the trailing edge thereof, wherein the leader segment has a cut-out area adapted to fit around a trunk lock mechanism when said cover means is in an extended position and said containment tube is in a stowed position, said cover means including means for attaching the cover means to the automobile at the front and rear bumper areas and side areas thereof;

(b) a containment tube having an open interior of sufficient volume to store said cover means and having a slot formed therein for passage of said cover means therethrough, said containment tube including a rotatable spool positioned therein, attached to the second end of the leader segment of the cover means;

(c) means for rotating said spool for winding said leader segment and cover means thereon, and;

(d) means for pivotally mounting the containment tube within a trunk portion of the automobile, wherein the containment tube is swingable to a position outside of the trunk portion for unwinding and winding in said cover means and swingable to a stored position within said trunk, whereby, in use, when the automobile is covered, the cover means extends forwardly from said containment tube to cover the front of the automobile and extends rearwardly from the attachment area of the leader segment to cover the rear of the automobile and said leader segment extends from said attachment area to the stored containment tube within the trunk.

2. The cover system of claim 1 wherein the means for attaching the cover means to the automobile includes an elastic, ribbon-like material affixed on at least said side and trailing edges thereof.

3. The cover system of claim 2 wherein the cover means includes a front section extending a distance from the leading edge thereof and constructed of an elastic-like fabric material and terminating at a forward end; a rigid guide wand attached to the forward end of said elastic front section for grasping by a user and for directing said cover over said automobile during covering and uncovering operation.

4. The cover system of claim 1 wherein the cover means is constructed of a nylon material and includes an elastic ribbon-like border material affixed on at least said side and trailing edges thereof.

5. The cover system of claim 1 wherein the means for mounting the containment tube comprises means

for pivotally mounting the containment tube within a trunk compartment of the automobile whereby in a first stored position the containment tube is positioned inside the trunk compartment and in a second, operable position, the containment tube is positioned outside of the trunk compartment adapted to dispense said cover means therefrom to cover the automobile and to reel in said cover means and subsequently assume said stored position both when the cover means is covering the vehicle and when the cover means has been removed from said automobile.

6. The cover system of claim 1 wherein the means for rotating the spool includes an electric motor positioned within said containment tube and operably connected to said spool and adapted to be powered by a battery and including means for activating and de-activating said motor.

7. The cover system of claim 6 wherein the means for activating and de-activating the motor includes a remote transmitter means for sending a signal to a receiver means mounted in said containment tube.

8. The cover system of claim 1 wherein the means for rotating the spool includes spring means associated with said spool which is adapted to windably store energy when the cover means is unwound from the spool and adapted to release said stored energy to rotate said spool when said cover means is wound to a stored position.

9. The cover system of claim 8 including control means for releasing the spring means to rotate the spool when the cover means is to be wound on said spool.

10. The cover system of claim 9 wherein the spring release means includes a remote transmitter means for sending a signal to a receiver means mounted in said containment tube and operably interacting with a solenoid device for releasing said spring means upon reception of a signal from said remote transmitter means.

11. The cover system of claim 1 wherein the means for rotating the spool includes a manually turnable crank means attached to said spool, having a handle extending outwardly from an end of the containment tube for hand winding of the cover means.

12. The cover system of claim 1 wherein the attachment area of the leader and cover means is positioned between about one-quarter to one-third the length of said cover means from the trailing edge thereof.

13. The cover system of claim 1 wherein the means for rotating the spool comprises an electric motor and further includes means for sensing rotative movement of said spool during rotation thereof by the motor and for deactivating the motor when the sensing means senses a non-rotative condition.

14. The cover system of claim 13 wherein the sensing means includes a plurality of permanent magnets positioned a spaced-apart way around a rotatable disc carried by the spool at one end thereof and stationary sensor means adjacent the disc and circuitry means for sensing an oscillating magnetic field as the magnets move past the sensor means and for de-activating the motor when the sensor means detects an absence of the oscillating magnetic field.

15. A cover system for an automobile comprising:

(a) a ***flexible cover*** means having a leading edge and a spaced trailing edge defining a length therebetween and opposed side edges, said cover means of a size suitable for covering the automobile

from a rear bumper to a front bumper and around the sides thereof; said cover means including a leader segment having first and second ends attached along its first end to the cover means defining an attachment area positioned substantially mid-way between said side edges and spaced from the trailing edge thereof, said cover means including means for attaching the cover means to the automobile at the front and rear bumper areas and side areas thereof and wherein the leader segment of the cover means includes means located between the first and second ends thereof to permit detachment of the leader segment and cover means from the containment tube;

(b) a containment tube having an open interior of sufficient volume to store said cover means and having a slot formed therein for passage of said cover means therethrough, said containment tube including a rotatable spool positioned therein, attached to the second end of the leader segment of the cover means;

(c) means for rotating said spool for winding said leader segment and cover means thereon; and

(d) means for pivotally mounting the containment tube within a trunk portion of the automobile, wherein the containment tube is swingable to a position outside of the trunk portion for unwinding and winding in said cover means and swingable to a stored position within said trunk, whereby, in use, when the automobile is covered, the cover means extends forwardly from said containment tube to cover the front of the automobile and extends rearwardly from the attachment area of the leader segment to cover the rear of the automobile and said leader segment extends from said attachment area to the stored containment tube within the trunk.

16. The cover system of claim 15 wherein the detachment means carried by the leader segment is a zipper.

17. In combination, an automobile and a cover system therefore comprising:

(a) a ***flexible cover*** means having a leading edge and a spaced trailing edge defining a length therebetween and opposed side edges, said cover means of a size suitable for covering the automobile from a rear bumper to a front bumper and around the sides thereof, said cover means including an elastic, ribbon-like material affixed on said edges, said cover means including a leader segment having first and second ends and attached along its first end to the cover means and defining an attachment area therealong and positioned substantially mid-way between said side edges and spaced from the trailing edge thereof, and including means for attaching the leading edge of the cover means to one of said bumpers;

(b) the other of said automobile bumpers having an open interior and having an opening formed along an outer surface thereof communicating with the bumper interior;

(c) a containment means positioned within said open bumper interior to store the cover means therein, said containment means including a rotatable spool positioned therein and attached to the second end of the leader segment of the cover means; and

(d) means for rotating the spool for winding said leader segment and cover means on the spool, wherein the spool rotation means comprises a motor having control means including a timer means adapted to be activated by a user, whereby the motor is energized when a predetermined time period elapses after said timer means is activated.

18. The cover system of claim 17 including a rigid guide wand attached to the cover means adjacent the leading edge thereof.

19. The cover system of claim 17 wherein the containment means is located in the rear bumper and wherein the cover means includes a front section extending a distance from the leading edge thereof and constructed of an elastic-like fabric material and terminating in a forward end carrying a rigid guide wand thereon, said elastic front section also having a cut-out portion adapted to fit around a bracket means at a front bumper of the automobile.

20. A cover system for an automobile comprising:

(a) a ***flexible cover*** means having a leading edge and a spaced trailing edge defining a length therebetween and opposed side edges, said cover means of a size suitable for covering the automobile from a rear bumper to a front bumper and around the sides thereof; said cover means including a leader segment having first and second ends attached along its first end to the cover means defining an attachment area positioned substantially mid-way between said side edges and spaced from the trailing edge thereof, said cover means including means for attaching the cover means to the automobile at the front and rear bumper areas and side areas thereof;

(b) a containment tube having an open interior of sufficient volume to store said cover means and having a slot formed therein or passage of said cover means therethrough, said containment tube including a rotatable spool positioned therein, attached to the second end of the leader segment of the cover means;

(c) means for rotating said spool for winding said leader segment and cover means thereon, wherein the spool rotation means comprises a motor having a control means including a timer means adapted to be activated by a user, whereby the motor is energized when a predetermined time period elapses after said timer means is activated; and

(d) means for pivotally mounting the containment tube within a trunk portion of the automobile, wherein the containment tube is swingable to a position outside of the trunk portion for unwinding and winding in said cover means and swingable to a stored position within said trunk, whereby, in use, when the automobile is covered, the cover means extends forwardly from said containment tube to cover the front of the automobile and extends rearwardly from the attachment area of the leader segment to cover the rear of the automobile and said leader segment extends from said attachment area to the stored containment tube within the trunk.

21. A cover system for an automobile comprising:

(a) a ***flexible cover*** means of a size suitable for covering the automobile;

(b) a containment tube adapted to be positioned within a bumper of the automobile, said tube having an open interior to store said cover means therein and having a slot formed therein for passage of said cover means therethrough and to an exterior portion of said bumper, said containment tube including a rotatable spool positioned therein attached to said cover means; and

(c) means for rotating the spool for winding the cover means thereon, wherein the spool rotation means comprises a motor having control means including a timer means adapted to be activated by a user, whereby the motor is energized when a predetermined time period elapses after said timer means is

activated.

Description

BACKGROUND OF THE INVENTION

The present invention relates generally to automobile covers and more particularly to covers that can easily be removed from a vehicle mounted storage and moved into a covering position around the auto. The invention also relates generally to the configuration of such covers for fitting around the vehicle which provides trouble-free retraction into a stored position within the containment tube. Still further, the invention relates to the mounting arrangement of the containment tube and the storage thereof within the trunk compartment when the cover is in use. In a further embodiment, the cover and containment tube are located within a bumper, preferably the rear bumper of the automobile.

Heretofore, it has been common to use lightweight covers of various flexible fabric materials to cover vehicle bodies for protection against the elements. Covers are often used to protect automobile paint finishes from the harmful effects of the sun and airborne dirt and smog, rain, snow and the damaging abrasive effects of windblown sand, for example. Covers are also used as a solar shield to keep the interior of the vehicle cool in hot, sunny climates. Most commonly, vehicle covers are shaped to surround the top, front, rear and sides of the car body, having an elastic band sewn around the bottom periphery thereof to permit the cover to snugly fit underneath the bumper and fender areas of the car. These prior covers are usually put on and/or removed by hand and are commonly stored in a folded condition in the trunk compartment when not in use. Needless to say, the application of such covers, particularly with lightweight nylon covers, is somewhat cumbersome and time consuming, especially for one person. It is also somewhat difficult to remove and fold the cover for compact storage within the trunk compartment.

Various devices have been proposed heretofore to provide a cover reel on which the vehicle cover is stored when not in use and unwound when the cover is to be applied to the vehicle. It is also known to employ a motorized reel to assist in winding the cover to a stored position within a cylindrical housing. Heretofore, however, such devices have been either fixed to the front or rear exterior of the vehicle and are targets of theft, or they require significant alterations to the vehicle body in order to permit the cover to operate properly. In addition, prior cover configurations are difficult to wind on a rotating reel or spool without experiencing snagging or jamming problems. These shortcomings are eliminated by the present invention.

SUMMARY OF THE INVENTION

The present invention overcomes the problems encountered in prior art vehicle cover devices by providing a containment tube which, in one preferred form, is pivotally mounted within the trunk compartment of the vehicle and is stowed within the trunk compartment. The containment tube is pivotally swung outwardly from the trunk to a second position located exterior of the trunk and the cover withdrawn from the containment tube to cover the car. The containment tube is then pivotally returned to the trunk and locked therein for security reasons. The containment tube is hollow and generally cylindrical in shape and possesses a sufficient volume to accommodate the rolled leader segment and ***flexible cover*** therein. The containment tube also has a longitudinally extending slot formed therein to permit ingress and egress of the cover and leads. The unique cover of the present invention comprises a

flexible fabric of nylon, for example, having a shape to overlay the roof, front, rear and side portions of the vehicle. The cover has leading and trailing edges. The leading edge of the cover preferably has a front section of an elastic fabric, with a rigid guide wand attached thereto and is adapted to be secured to the front bumper region of the car. The side and trailing edges of the cover include a ribbon or band of elastic material sewn around the perimeter thereof to provide for a snug fit around the lower regions of the rear bumper and side fenders. A leader segment constructed of an elastic material is secured at a first end to a rotatable spool positioned within the containment tube and secured at a second end to the flexible cover at a spaced distance approximately one-quarter to one-third the cover length from the trailing edge of the cover. This configuration reduces the number of spool revolutions necessary to retract the cover into the containment tube since the cover is pulled into the tube in a doubled-over fashion until the rear section of the cover is completely retracted into the containment tube. The leader segment preferably has a cut-out portion to fit around the trunk lock mechanism when the cover is on the car and the containment tube is stowed in the trunk compartment.

The spool within the containment tube is preferably rotated by an electric motor which is powered by the vehicle battery. A remote control circuit and remote actuation device is also preferably employed to activate the motor when the cover is to be retracted and wound within the containment tube. In use, the cover is unwound from the take-up spool of the containment tube, either in a free wheeling or power assisted mode, by the user who grasps and directs the guide wand at the leading edge of the cover. The elasticized front section at the leading edge of the cover may include a cut-out portion to fit around the license plate and/or bracket at the front bumper in order to provide a convenient attachment scheme. In the installed condition, the cover is completely removed from the containment tube such that the elastic leader segment extends outwardly from the containment tube slot a distance to permit the trailing edge of the cover to be grasped and pulled rearwardly to cover both the containment tube and the rear bumper of the vehicle. When this rear portion is so fitted, the elasticized border portions at the side edges of the cover simultaneously move downwardly to slip beneath the bottom edges of the fenders along the sides of the vehicle providing a very snug and attractive appearance. The containment tube is also completely concealed by the vehicle trunk when the cover is in the installed position.

When the cover of the invention is to be removed from the vehicle, the containment tube is pivoted from the trunk. The trailing edge portion of the cover is pulled away and upwardly from the rear bumper and rear fender areas of the car and allowed to assume a position above the containment tube, i.e., in a position between the containment tube and the rear window of the vehicle. The elastic border material is sewn into the cover bottom in a manner that causes the cover to naturally gather in the area of the rear window as soon as the lower region of the cover is unhooked from the rear bumper/fender area. The leading edge of the cover is then removed from the front bumper and front fender area of the vehicle and the remote control motor switch is then activated. The containment tube is pivotally mounted such that the slot of the containment tube which receives the cover is positioned near or above the surface of the trunk lid deck so that there is minimum surface contact with the cover to decrease the chance of snagging as the cover is reeled. The heavier elasticized fabric leader material is first wound around the rotating spool of the containment tube which then guides the cover as it is reeled within the containment tube to provide virtually trouble-free reeling and storage. A safety overload or torque overload device, preferably in the form of a cyclic magnetic switching system or in the form of a spring- loaded torque plate, may be employed within the motorized drive unit in order to sense any snags which may occur during the cover take-up operation. Such unavoidable cover snags may result from the cover catching on a side mirror of the vehicle or on a door handle or the like. The torque overload device senses any increased tension on the cover and the take-up spool or senses a stoppage of rotation and immediately shuts off the motor in order to prevent overloading thereof and/or ripping of the cover. The obstruction is removed and the

motor restarted to complete the winding operation. In place of the remote control system, a timer control may be employed to energize the electric motor after a given time delay to permit the operator to move to the front of the car and direct the guide wand back to the rear. When the cover is completely wound around the spool, the containment tube is pivotally moved to its stored position within the trunk compartment and the trunk lid closed and locked with the containment tube and cover safely stowed therein.

A further presently preferred embodiment of the invention contemplates mounting the containment tube within the hollow confines of a car bumper, preferably the rear bumper thereof. Such an embodiment is particularly suited for installation as original equipment at an auto plant.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation view of an automobile with the vehicle cover system of the present invention in place thereon;

FIG. 2 is a partial perspective view of the rear portion of an automobile showing the containment tube of the present invention swung outwardly from a trunk compartment thereof;

FIG. 3 is a partial perspective view similar to FIG. 2 showing the containment tube swung inwardly to a stowed position within the trunk compartment;

FIG. 4 is a side view of an automobile similar to FIG. 1 showing the cover system of the present invention in a partially installed position;

FIG. 5 is a fragmented perspective view of a presently preferred embodiment of a fabric car cover, according to the present invention;

FIG. 6 is a cross-sectional side view of one embodiment of a containment tube having a motorized spool according to the present invention;

FIG. 7 is a cross-sectional end view of a presently preferred embodiment of a containment tube and guide wand of the present invention;

FIG. 8 is a schematic drawing of the control circuitry, useful in the present invention, including wireless remote control transmitter and receiver devices and drive motor;

FIG. 9 is a cross-sectional side elevation view of a containment tube and motor powered spool having a magnetic field analyzer shut-off feature according to the invention;

FIG. 10 is a cross-sectional view of a containment tube similar to FIG. 6, but having a spring-biased spool winding device including a remote actuation control feature;

FIG. 11 is a partial perspective view of the front of the vehicle with the cover of the invention installed thereon;

FIG. 12 is a side elevation view of an automobile similar to FIG. 1 except that the containment tube is enclosed within the trunk compartment;

FIG. 13 is a partially fragmented, cross-sectional side view of the containment tube drive motor having a manually activated, time delay control;

FIG. 14 is a partial fragmented view of a rear portion of an automobile showing the containment tube of the present invention mounted within the rear bumper of the automobile;

FIG. 15 is a partial fragmented view similar to FIG. 14 showing the vehicle cover partially removed; and

FIG. 16 is a cross-sectional end view of the rear bumper and containment tube taken along lines XVI--XVI of FIG. 14.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and, specifically to FIG. 1, the vehicle cover system of the present invention generally designated 2 is shown in the fully installed condition surrounding a vehicle generally designated by reference numeral 4. The cover system 2 includes a ***flexible cover*** portion 6, the details of which are shown in FIG. 5, and a containment tube 8 mounted adjacent a rearward end of the car trunk. An elasticized leader segment 10 connects the cover 6 to a rotatable spool 9 located within the containment tube 8. As shown in greater detail in FIG. 5, the elastic leader segment 10 is sewn or otherwise attached to the fabric cover 6 at an attachment area 10'. A smaller segment 11 is attached to the leader 10 by way of a zipper 13, preferably of nylon which, in turn, is connected to the spool at edge 11'. The ***flexible cover*** 6 is preferably constructed of a lightweight nylon material. A variety of synthetic and natural materials, including nylon, dacron, cotton, acetylated cotton, and blends of natural and synthetic materials may be used as the primary material for the fabric cover 6. The preferred material is nylon because of its lightweight, strength, cost, and resistance to mildew and the like. The cover 6 also is constructed of a fabric having a light color, so as to reflect the rays of the sun away from the vehicle to thus keep it cool. Due to the fact that the cover material is in intimate contact with the vehicle surface, ideally a cover with a light color on the outer side and a dark color on the inner side is preferred. In this manner, the light outer color reflects the sun away from the cover surface while the darker color on the under side absorbs heat radiated and conducted from the vehicle's surface beneath, thereby transmitting heat away from the covered vehicle's surface.

The cover 6 includes a leading edge 12 and a trailing edge 16 adapted, respectively, for placement at the front and rear bumpers. The cover also includes side edges 14 which extend between the leading and trailing edge portions on opposite sides of the vehicle. The cover 6 preferably includes a ribbon-like band of elastic border material 15, on the order of about 1/4 inch wide, sewn around its perimeter. The band of elastic ribbon-like border 15 extends from the leading edge 12 around the sides 14 to the trailing edge 16 to permit the peripheral edges of the cover to fit snugly around the lower regions of the vehicle body as shown in FIG. 1.

The leading edge 12 of the fabric cover 6 also includes an elastic fabric front section 18 which extends rearwardly therefrom and is joined to the cover 6 by way of a stitched seam 19, for example. The elastic front section 18 carries a rigid, rod-shaped guide wand 20 which is fitted around a loop-like bead 52 formed at the end of section 18; see FIG. 7. A cut-out area 22 is formed within the elastic front section 18 which may conveniently fit around the front license plate bracket for securement purposes. In addition, or in place of the cut-out portion, the lower front bumper area of the vehicle 4 may be fitted with a pair of small clamps or like means for holding the wand 20 in place (not shown).

The cover 6 of the present invention represents a significant improvement over prior covers which are reeled into storage housings, principally due to the unique feature of the elastic leader segment 10 which joins the cover 6 to the rotatable spool 9 of the containment tube. Elastic leader 10 is, by way of example, about 24" in width, which is approximately the length of an entry slot 24 formed in the containment tube 8, FIG. 2. The leader 10 is also, for example, about 2 feet in length from the attachment seam 10' with the cover 6 to the terminal end 11', which is attached to the rotatable spool 9 of the containment tube. The location of the elastic leader segment 10 relative to the cover 6 is important and, in this regard, we prefer to place the seam 10' joining the leader segment 10 to the cover 6 approximately one-quarter to one-third the cover length from the trailing edge 16. For example, if the cover 6 has a length of approximately 16 feet from the leading edge 12 to the trailing edge 16, the leader segment 10 would preferably be affixed at 10' to the cover 6 between about 4 to 5 feet from the trailing edge 16. In this manner, an aft section of the cover 6 is defined as the section extending from seam 11' to the trailing edge 16. The aft section of the cover 6 extends rearwardly to cover the containment tube 8 and the rear trunk and bumper portions of the vehicle when the cover is in the installed position as shown in FIG. 1. Conversely, when the cover 6 is to be removed, as shown in FIG. 4, the aft section is lifted from beneath the rear fenders and bumper area of the vehicle to assume, by virtue of the elastic border 15, a position above the containment tube 8. In the position shown in FIG. 4, the side edges 14 of the cover 6 assume a posture, due to the elastic leader segment 10, extending diagonally from the area of the front bumper to a point forward of and slightly above the inlet slot 24 of the containment tube 8. When the guide wand 20, carried by elastic front portion 18 of the cover 6 is upwardly moved to disengage the front of the vehicle 4, the take-up tube is activated to reel in the leader segment 10. The cover 6 follows the leader 10 in a very neat and orderly fashion due to the high position and feeding alignment afforded by the elastic leader 10 and location of the containment tube adjacent the top of the trunk lid 5. The retraction of the cover is also facilitated since the cover is pulled into the containment tube in a doubled-over or double-layered configuration until the entire aft portion of the cover is retracted.

The containment tube 8 is fitted with a pair of spaced-apart mounting straps 26 which include hinged fittings 28. The straps 26 are adapted to be secured to a rear wall of the trunk compartment of the vehicle 4. The mounting straps 26 are preferably of a high strength stainless steel material of relatively thin gauge, for example, 0.60 inches thick to permit the trunk lid 5 to close over the straps 26 when the containment tube 8 is outside, in the operable position shown in FIGS. 1, 2 and 4. The straps may also be constructed of stainless steel mesh or plastic. After the cover 6 has been wound on a spool 9 and stored within the containment tube 8, the containment tube is pivotally swung about the hinges 28 to a stowed position within the trunk compartment, as shown in FIG. 3. The trunk lid 5 is then closed and the car cover device 2 of the invention is safely locked within the confines thereof.

The leader segment 10, as stated above, is preferably constructed of an elastic-like stretchable material, for example, the material sold under the trademark "Spandex" is particularly suitable. This same fabric is also suited for use in the front section 18. The front bumper area of the vehicle 4 may also be equipped with "C"-shaped spring clips (not shown) to engage and retain the tube-like guide wand 20 when the cover is in the extended position shown in FIGS. 1 and 4. Retention spring clips are useful for those vehicle designs which do not possess a protruding license plate bracket for engagement with open slot 22 of the front section 18.

The spool 9 of the containment tube 8 can be rotated either manually, by spring tension, or by a motor assist drive. As shown in FIG. 6, the containment tube 8 and spool 9 may be constructed in a telescoping fashion with slidable nesting sections to accommodate various sizes and ***weights*** of vehicle covers. The

telescoping action is but one of many various forms the containment tube 8 may take within the context of the overall invention. We prefer, however, to form the containment tube 8 as a single, unitary cylindrically-shaped hollow tube as shown in FIGS. 2 and 3. The containment tube 8 may be manufactured from either plastic or metal pipe and cut to length with the slot 24 formed through the sidewall by appropriate means along its longitudinal length. A pair of end plates 30 are secured to the ends of the containment tube 8. The take-up spool 9 is rotatably mounted preferably on bearings within the containment tube 8. As shown in FIG. 6, spool 9 may be rotatably driven by a drive motor 32. A 12 volt DC 100-150 rpm motor, having a wireless control receiver and receiver/motor interface logic and circuitry, generally indicated as 34, is connected thereto and mounted within a chamber formed between the end plate 30 and a motor mounting plate 36.

In the telescoping containment tube embodiment shown in FIG. 6, the take-up spool 9 is made up of two tubular shafts 38 and 40 mounted for rotation at their ends within stationary end plates 30 and 36. A central extension rod 42 is slidably fitted within the tubular bores of the shafts 38 and 40 to permit adjustment of the length of the containment tube 8. Set screws 44 are fitted within the tubular shafts 38 and 40 to secure the extension rod 42 therein when the desired length is established. The drive shaft tubes are preferably constructed of aluminum tubing stock while the extension rod 42 may be of a stainless steel material to provide a strong joint between the rotating members. Of course, other materials may be employed, such as high strength plastic materials for the central extension rod and tubular shafts and end plates.

The rotatable spool 9 is driven by a motor shaft 46 which extends from the motor 32 through the mounting plate 36 and into the tubular bore of the shaft member 40. A set screw 48 or like keying element engages the sidewall of the tubular shaft 40 to cause the spool 9 to rotate with the motor driven shaft 46.

The edge 11' of the elastic leader 10 is fastened to the take-up spool 9 by way of an attachment segment 11 which is connected to the main leader 10 preferably by a zipper 13, or by snaps, or by a Velcro-type fastener. Having a zipper in the attachment segment 11 permits the cover to be removed from the spool and containment tube for washing, cleaning, waterproofing and the like, or for thorough drying purposes. The attachment segment is secured to the spool 9 by either slitting the spool, inserting and fastening the end of the leader into the slit; or by using mechanical fasteners such as screws, rivets, tape, adhesive materials or the like. The attachment segment 11 may be constructed of elastic material similar to the leader segment 10, however, this is not absolutely necessary. As stated above, the width of the attachment segment 11 and the leader segment 10 are several feet in width and substantially are of the same dimension or slightly less than the length of the slot 24 formed in the containment tube 8.

The cylindrical containment tube 8 may be configured in cross-section as a circle or it may assume an elongated eccentric or oval shape as shown in the cross-sectional view of FIG. 7. In this embodiment, the entry slot 24 for the cover is formed by two inwardly formed curling lips 50, which may conveniently be formed by way of an extrusion, for example.

As best seen in FIG. 7, the leading edge 12 of the front portion 18 has a bead portion 52 formed therealong, which is adapted to be fitted into a hollow interior 54 of the control wand 20. The wand 20 has a longitudinal slot 56 formed therein to permit the wand to be slid over the cover and to permit the beaded portion 52 to reside within the hollow interior 54. The diameter of beaded portion 52 is larger than the width of the slot 56 and hence, the guide wand remains attached to the end of the cover 6 by way of this interference fit. End caps are fitted at each end of the guide wand. The wand 20 also

preferably contains a widened channel portion 58 which retains a remote control transmitter unit 60, preferably by a snap fit therein. The remote control unit 60 has a switch or button 62 for activating the unit and subsequently sending a signal to the radio receiving control means 70 mounted adjacent the motor 32, or other means mounted in the containment tube 8. As shown in FIG. 7, the containment tube 8 also preferably contains a plurality of spaced-apart drain holes 64 formed through a lower surface thereof to permit accumulated water from the cover 6 to drain therethrough. The drain holes 64 also permit entry of air into the containment tube to maintain the cover in a lower humidity environment within the confines of the containment tube.

FIG. 8 is a schematic showing one presently preferred embodiment of the control circuitry useful in connection with the present invention. The wireless remote control means 60 houses a switch button 62 and a radio frequency transmitter 66. A wireless receiver station 68, mounted in the containment tube 8, houses a wireless control receiver 70, with a conventional receiver antenna 72, receiver/motor interface logic circuitry 74 and the drive motor 32. Electrical power to energize the motor is supplied by a conventional vehicle battery 7. The wireless control receiver 70 is located between the motor mounting end plate 36 and the end plate 30 and is activated by a radio signal 76 transmitted from the radio frequency transmitter 66, which, as stated above, may be housed in the guide wand 20. After the cover is installed on the car, the transmitter control unit 60 is preferably unsnapped from the wand and carried by the vehicle operator so as to prevent unauthorized removal of the car cover from the vehicle. In place of a radio signal 76, ultrasonic, infrared, microwave or other transmission media could also be used as a wireless control link between the remote unit 60 and the receiver station 68.

The cover drive motor 32 is activated through a motor/receiver interface logic and circuitry housed in black box 74, which also contains a relay system which may be either solid state logic, or mechanical, to activate the motor 32. The circuitry logic is preferably designed such that the remote motor control button 62 must be depressed to permit the operation of the winding/unwinding drive motor. Limit control switches 17 may also be used to turn the motor off when the cover has reached either its fully extended, or fully retracted, positions. The circuitry is also designed such that the motor rotation may be reversible with a single button control.

A further motor control shut-off scheme is shown in FIG. 9 which provides a safety shut off in the event of cover snagging and functions as a torque overload device. In this presently preferred embodiment, the take-up spool 9 of the containment tube 8 has a rotatable end disc 78 attached thereto for rotation adjacent the stationary motor mounting end plate 36. The disc 78 has a plurality of permanent magnets 80 affixed around the perimeter thereof. A stationary magnetic sensor 82 is affixed to the mounting plate 36 to monitor the oscillating magnetic field created by the magnets as the spool end disc 78 rotates past the sensor. The magnetic sensor 82 is connected to a periodic magnetic field analyzer circuitry represented by black box 84 which, in turn, is wired to the motor 32. The sensor 82 continuously monitors the oscillating magnetic field generated as the magnets 80 pass in front of the sensor as the take-up spool end disc 78 rotates during a normal cover winding operation. When the spool 9 stops rotating due to a snag or when the guide wand 20 reaches the inlet slot 24, the sensor 82 immediately recognizes a cessation in the oscillating magnetic field and the solid state periodic magnetic field analyzer circuitry 84 immediately causes the motor to shut off, thus preventing an overload in the motor and/or damage to the cover 6 if it were, for example, snagged on a side mirror, door handle, or the like. Once the snag is cleared, control button 62 on the remote transmitter 60 is pressed and the motor 32 is restarted if additional winding of the cover is required. The magnetic sensor control unit is also useful for automatically stopping the motor 32 when the wand 20 reaches the tube 8 to shut the motor off at the end of the winding cycle.

The take-up spool 9 and containment tube 8 may also be equipped with a manually operated crank handle or like device to permit manual winding of the spool 9 as an alternate embodiment. Such a manual feature may also be incorporated with the motorized embodiment to provide a back-up system for winding the spool 9.

A still further preferred embodiment of the present invention, depicted in FIG. 10, employs helical springs 86 to supply the energy to wind the cover 6 into the cylindrical containment tube 8. Naturally, in this embodiment, the previously described motor 32 is eliminated. The two helical retractive spring elements 86 are mounted around the shafts 38 and 40 of the spool 9. Respective ends of each of the helical springs 86 are mounted in a hole in the mounting end plate 30' and in the mounting plate 36'. The other ends of the springs are mounted in respective holes formed in the drive shafts 38 and 40. Each of the springs 86 are covered by a pair of protective cylindrical tubes 88. A remote controlled solenoid device 90 is situated adjacent to a plate 36' mounted within the containment tube. A circular indexing disc 92, having a spaced array of index holes formed around its perimeter is rotatably mounted through the plate 36' with a lock washer and mounting nut system. The indexing disc 92 is locked to the shaft 40 of the spool 9 and rotates therewith. When the solenoid 90 is energized, a magnetically actuated pin 94 in the solenoid is withdrawn from one of the holes in the indexing disc 92 which releases the locked spool 9 and allows the helical springs 86 to rotate the shafts 38 and 40 of the spool 9. The cover 6 is, in the embodiment of FIG. 10, manually withdrawn from the containment tube and pulled over the vehicle using the guide wand 20 to apply the fabric cover 6 over the surface of the vehicle 4. The pulling movement of the cover causes the spool 9 to rotate and thus stores the needed energy in the springs 86 as they are compressively wound by the rotating spool 9. The wound springs 86 are then locked in place after the cover has been reeled in by setting the solenoid pin 94 in one of the indexing holes in the disc 92. The solenoid 90 is activated by a radio signal sent from a remote control means and received by a wireless control receiver 70'. A receiver/motor interface logic and circuitry system 74' is also included. When the solenoid 90 is energized, the pin 94 is retracted from a hole in the indexing disc 92 to release the stored energy in springs 86 to rotate spool 9 and retract the cover 6. The guide wand 20 is used during retraction to direct the cover over the vehicle surface into the containment tube 8. The cover 6 can also be wound on the reel 9 manually as shown on the left hand portion of FIG. 9. A rotatable hand crank 21 having an outwardly extending handle 23 is situated at an end of the containment tube 8. The hand crank 21 is coupled to spool 9 by a shaft 27 to permit the spool to be rotated when the handle 23 is turned. This manual winding feature may be used alone or in combination with one of the above-described motorized or spring-biased winding embodiments.

The usefulness of this invention stems from the simplicity of its function and design and subsequent ease of manufacturing and ultimate use. The remote control feature and guide wand allows for precise control of the take-up spool winding and unwinding when extracting or retracting the vehicle cover. The covering or uncovering operations are easily accomplished with one hand, even in windy conditions. Because of the speed in which the covering or uncovering operations are performed, especially in covering, a blanket of trapped air between the cover and the car body serves to float the cover onto the vehicle.

One slightly modified form of the present invention is seen in FIG. 12. In this embodiment, the containment tube 8' is shown stowed in the trunk compartment when the cover 6 is positioned on the vehicle. In order to accomplish this configuration, the leader segment 10 has a greater length than the previously described embodiments of FIG. 1 so that it can extend from the connection point 10' to the containment tube 8' positioned in the trunk compartment. The leader segment 10 also has a cut-out portion 10" formed therein, FIG. 5, which is adapted to fit around the trunk locking latch when the

containment tube is stowed in the trunk and the trunk lid is closed thereon as in FIG. 12. In this way, the trunk lid is permitted to properly latch without damaging the fabric of the leader segment 10.

A further modified form of the invention is depicted in FIGS. 14-16. In this presently preferred embodiment, the containment tubes and vehicle cover of the invention are fitted within the confines of one of the vehicle bumpers, preferably the rear bumper 100. The bumper 100 has an elongated opening 102 formed in an upper surface thereof to permit the vehicle cover 106 and wand 120 to pass therethrough. The opening 102 preferably has a moveable flap 103 positioned adjacent thereto and hinged to the bumper 100 to close off the opening when the cover 106 and wand 120 are stowed within the interior of the bumper 100. Of course, other closures such as a slidable door or the like element could be employed in place of the flap 103 to close off the opening 102.

Ideally, the cover system of the invention is built into the bumper 100 at the time the new vehicle is being constructed at the auto assembly plant. While I have shown the cover 106 housed within the containment tube 108 which, in turn, is attached by fasteners 104 to the bumper, FIG. 16, it is, likewise, possible to eliminate the containment tube 108 and have the bumper 100 function in place thereof. When the containment tube 108 is employed, it may be desirable to design the bumper 100 with removable end portions 101 to provide easy access to the interior of the bumper for installation of the containment tube 108 therein. The containment tube 108 could also be installed within the bumper 100 through the open rear face 105 of the bumper (FIG. 16) prior to attachment of the bumper to the vehicle frame. These, as well as other alternative installation procedures will naturally occur to those skilled in automotive assembly art. It is also preferable in such in-bumper new vehicle installation to wire the motor 32 and related controls directly into the conventional battery powered electrical system of the vehicle. Of course, it is also understood that the in-bumper form of my invention can also be installed as a retrofit on new or used vehicles after they leave the auto assembly plant merely by replacing the existing bumper with a compatible slotted bumper of the previously described type.

Referring to FIG. 13, the present invention may also include a timer control device 110 positioned adjacent motor 131 with the containment tube 108. An activation switch 112 is mounted on an outer surface of the bumper 100 and operably connected to the timer device 110 by wiring 114 or suitable mechanical linkage. The switch 112 is preferably key actuated to prevent unauthorized starting of the motor 131. After the user/operator activates the timer control device 110, the user has sufficient time to walk to the other end of the vehicle and grasp the wand 120 prior to the activation of the motor 131 and winding reel 109 by timer 110. The cover is then "walked-in" to the in-bumper containment tube 108 as previously described. The timer control device 110 and associated activation switch 112 thus provide a less expensive power assisted alternative to the previously described remote control system of FIG. 8.

It is further contemplated that a magnetic reed switch or mechanical switch be provided on a front portion of the wand hold-down hook (not shown) which is wired into the existing security system of the automobile to prevent tampering with the cover. Of course, the cover security system may also be wired to a key-operated switch such as switch 112 in order to activate and deactivate the security system.

The transmitter control unit 60 can also be used to remotely open the vehicle trunk by using a magnetic proximity switch to sense if the cover 6 is in the containment tube 8, thereby activating the remote trunk control.

Having thus described our invention with the detail and particularity required by the Patent Laws, what is claimed and desired to be protected by Letters Patent is set forth in the following claims.

US PATENT & TRADEMARK OFFICE

PATENT FULL TEXT AND IMAGE DATABASE

United States Patent **5,579,794**
Sporta **December 3, 1996**

Apparatus and method for securing an object against gale-force winds

Abstract

Method for shielding, anchoring and containing an object such as a trailer or motor home in gale-force winds. A wind-permeable perforate sheet extends downwardly and outwardly from the top of the object or the roof of a home at an acute angle so as to surround a substantial portion of each of the sides with an inclined wind-permeable planar surface. The sheet is anchored to helical ground anchors via mechanical attachments which may also be used to tighten the sheet over the object or home. Apparatus for shielding, anchoring and containing an object such as a trailer or motor home in gale-force winds is also disclosed.

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Intern'l Class: E04H 012/20
Field of Search: 135/88.01,88.05,88.1,913,90,115 52/3,4,23,DIG. 11,155

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Parent Case Text

RELATED APPLICATIONS

This is a continuation-in-part of Ser. No. 08/095,006, filed Jul. 23, 1993, now abandoned, which is a continuation-in-part of Ser. No. 08/041,498, filed Apr. 1, 1993, now abandoned.

Claims

I claim:

1. Apparatus for shielding, anchoring and containing a trailer or mobile home in the event of gale-force winds, the trailer or mobile home having a roof and outer side walls, the apparatus comprising;

a substantially wind-permeable perforate sheet means of a resiliently flexible material having a surface area substantially greater than a combined surface area of a roof and the outer side walls of a mobile home and adapted for placement over the roof and extendable downwardly and outwardly from said roof at an acute angle to said outer side walls of said home, said sheet means being constructed and arranged to deflect or restrain windborne debris having an impact energy sufficient to damage said home by distribution of the impact energy throughout said material when the debris contacts the material;

a plurality of ground ***anchor*** members adapted for placement in the ground surrounding said home; and

attachment means, attachable to said perforate sheet means along a periphery thereof, for securing said perforate sheet means to ground ***anchor*** members thereby anchoring said home to the ground,

wherein said sheet means comprises a generally rectangular central sheet; opposing end sheets; and opposing side sheets, said end sheets and said side sheets being coupled to a periphery of said central sheet and each of said end sheets being coupled to an adjacent side sheet, said central portion being sized to correspond generally to the roof of said home and said side sheets and said end sheets being sized to extend downwardly and outwardly from said central portion at an acute angle to the outer side walls of said home.

2. Apparatus for shielding, anchoring and containing a trailer or mobile home in the event of gale-force winds, the trailer or mobile home having a roof and outer side walls, the apparatus comprising:

a substantially wind-permeable perforate sheet means of a resiliently flexible material having a surface area substantially greater than the combined surface area of the roof and the outer side walls of said home and adapted for placement over the roof and extendable downwardly and outwardly from said roof at an acute angle to said outer side walls of said home, said sheet means being constructed and arranged to deflect or restrain windborne debris having an impact energy sufficient to damage said home by distribution of the impact energy throughout said material when the debris contacts the material;

a plurality of ground ***anchor*** members adapted for placement in the ground surrounding said home; and

attachment means, attachable to said perforate sheet means along a periphery thereof, for securing said perforate sheet means to ground ***anchor*** members thereby anchoring said home to the ground,

wherein said sheet means comprises a central portion, defined by a generally rectangular strip member such that said central portion has an opening therein; opposing end sheets; and opposing side sheets, said end sheets and said side sheets being coupled to a periphery of said strip member and each of said end sheets being coupled to an adjacent side sheet, said central portion being sized to correspond generally to the roof of said home and said side sheets and said end sheets being sized to extend downwardly and outwardly from said central portion at an acute angle to the outer sidewalls of said home.

3. The apparatus according to claim 1, wherein said sheet means is constructed and arranged to withstand an impact energy of at least 500 Joules.

4. The apparatus according to claim 2, wherein said sheet means is constructed and arranged to withstand an impact energy of at least 500 Joules.

Description

FIELD OF INVENTION

The present invention relates to an apparatus and a method for securing objects, particularly, mobile trailer and motor homes against gale-force winds, and more particularly to a containment and protective apparatus and method for securing such objects to the ground and protecting and containing them in gale-force winds.

BACKGROUND OF THE INVENTION

Objects such as aircraft, small sail and motor boats, vehicles and particularly, trailer and motor homes, due to their light construction, large surface area and relatively low mass, are highly susceptible to damage and destruction from gale-force winds. Notably, gale-force winds have commonly been known to overturn such objects, or worse yet, lift and/or blow them a distance, resulting in severe damage and sometimes complete destruction of the object.

Aircraft are typically anchored to the ground by lines, straps, chains and the like to specific parts associated with the wheels or struts of the aircraft.

Objects such as small watercraft, power and sail boats, typically, rest on cradles or blocks formed of wood or steel when stored on land or are merely restrained by lines secured to an adjacent dockside or buoy when afloat. No other restraining means to prevent the boat from being hurled inland in the event of gale-force winds are employed.

Buildings, including residential homes and commercial and retail properties which typically rest on the ground by means of concrete footings and the like are often damaged by gale-force winds. In particular, roofs of buildings may be blown away. Further, the above objects are often damaged by flying debris created by the gale-force winds. Yet further, glasshouses for example, commercial greenhouses, are very susceptible to damage from windborne debris.

Vehicles are also often flung into the air and damaged by such winds.

Although netting has been used to embrace objects such as vehicles and aircraft, particularly as a means of carrying camouflage material, such netting has not been provided over the object as a secure retaining means sufficient to withstand gale-force winds and/or impact from flying debris.

Numerous prior art apparatus exist for securing mobile or trailer homes to the ground in the event of hurricane, flood, or gale-force winds. The majority of these prior art apparatus use a combination or ***anchor*** means, elongate strap members and tightening turnbuckles, whereby such strap members are placed over and encircle a mobile home and are affixed to ***anchor*** means via turnbuckles to ***anchor*** the mobile home to the ground.

U.S. Pat. Nos. 4,148,162, 4,070,802, 3,054,151, 3,335,531, 3,644,192, 3,747,288, 3,848,367 and

3,937,437 are all examples of such apparatus which secure a mobile home to the ground via elongate strap members placed over and encircling the mobile home.

For example, U.S. Pat. No. 3,054,151 and 4,070,802 each disclose "elongate metallic web-like hold-down straps 12 and 14" (U.S. Pat. No. '802) or "lashings 15" which bridge the roof of the mobile home and are secured at their ends to anchors.

Indeed, in some states within the United States of America where the incidence of hurricanes is high, such as in the State of Florida, State legislation requires that mobile homes be anchored to the ground in a stipulated manner requiring utilization of one or more of the above prior art apparatus and methods for securing mobile homes to the ground.

The above prior art apparatus, however, are often unsuccessful in preventing damage to mobile homes and small boats due to gale-force winds, since they completely fail to protect these objects from another source of damage, namely, damage due to impact with airborne debris, such as uprooted trees, bricks, flotsam, and the like which may impact the object at high velocity during a hurricane. For example, despite the utilization of such prior art apparatus, such prior art apparatus was unable to prevent the extensive damage and destruction to mobile homes which occurred in the state of Florida due to Hurricane Andrew in August of 1992. During this hurricane, trailer homes, despite being secured to the ground by prior art apparatus, suffered mass destruction due to being impacted by airborne projectiles such as trees, bricks, debris and the like, which so damaged trailer homes that the elongate strap members were completely ineffective in providing containment of the damaged trailer home. This often, and generally without exception, resulted in the damaged trailer home and its contents being completely blown away.

Accordingly, prior art apparatus do nothing to shield a mobile home from bombardment by airborne debris which frequently impacts a trailer home with such force so as to cause the break-up and disintegration of the mobile home. This is extremely undesirable, not only because of the destruction of the subject mobile home, but also because the resultant debris from the destroyed mobile home, including the mobile home's contents such as TV's, appliances, and the like, further add to the airborne debris circulating in a hurricane and in turn become airborne and impact and bombard other mobile homes, causing further resultant damage and destruction. Accordingly, the elongate strap members utilized with the apparatus of the aforementioned patents not only do nothing to shield a trailer home from airborne bombardment, but they further do nothing to prevent debris from damaged trailer homes and their contents from becoming airborne in a hurricane and causing further damage and destruction, both to human life and other property.

Use of canvas or nylon tarps or tarpaulins to protect property from wind and rain is also generally known. However, use of canvas tarps or tarpaulins, for the purpose of protecting mobile homes from damage from airborne debris in a hurricane, even if employed in the novel and inventive manner disclosed herein, would highly be unsuitable and indeed unworkable. In particular, to resist large volumes of wind, any canvas or nylon tarpaulins need to be of such thickness that their weight makes them extremely difficult to work with in placing over a trailer home, not to mention the increased expense in the number and size of ground ***anchor*** means necessary to retain the ***tarpaulin*** in high winds. In addition, once becoming rain-soaked, tarpaulins tend to sag, thereby trapping water and placing additional weight on the trailer, which, if such water were allowed to accumulate, may result in structural damage to the trailer home.

Accordingly, there exists a real need for a novel apparatus and method to shield and ***anchor*** property such as aircraft, boats, buildings and particularly, mobile homes from destruction in gale-force winds. In addition, there exists a further real need to contain resultant debris from any of such property which may

be destroyed due to impact from airborne debris to prevent such debris from itself becoming airborne and causing further destruction.

SUMMARY OF THE INVENTION

In order to overcome the disadvantages of the prior art, the present invention discloses a means/apparatus for simultaneously shielding, anchoring, and containing objects such as aircraft, boats, buildings, vehicles and trailer homes in the event of gale-force winds.

Advantageously, the apparatus of the present invention uses wind-permeable perforate sheets means, which in the preferred embodiment consists of flexible webbed netting, which may be placed in a prescribed manner over or around an object which is sought to be protected against impending gale-force winds or a hurricane. The flexible netting extends outwardly and downwardly at an acute angle from an upper part, preferably the top of the object and is affixed to ground anchors interspersed around the periphery of the object, to thereby ***anchor*** the net in place. In such manner, the object is contained within an enclosure, and each of the sides of the object are surrounded by an inclined sloped surface of the net.

Advantageously, by providing an inclined, substantially planar, sloped surface around the sides of the object, the object may thereby be protected from impact and bombardment by airborne debris during a hurricane, thereby preventing structural damage to the object. The inclined sloped surfaces of the net means allow substantial passage of wind therethrough, but prohibit passage of windborne debris such as bricks, stones, such as B3 gravel, trees, flotsam, wood spars and the like, which would otherwise impact and destroy or at least seriously damage, by penetration thereof or otherwise, the object. The perforate sheet means or net is of sufficient strength to resist impact with such projectiles, but further assists in preventing airborne debris from impacting the sides of the object by its sloped configuration, which assists in deflecting such airborne matter away from the sides of the object.

Accordingly, in its broadest aspect, the apparatus of the present invention comprises the combination of:

(i)an oversize wind-permeable perforate sheet means of a surface area substantially greater than the combined surface area of the top and sides of an object over which it is adapted to be placed, wherein such sheet means is extendable downwardly and outwardly from the top at an acute angle to the sides of the object;

(ii)a plurality of ground ***anchor*** means adapted for placement in the ground surrounding said object; and

(iii)attachment means, attachable to the periphery of the perforate sheet means, to allow the perforate sheet means to be secured to the ground ***anchor*** means.

In a further aspect of the present invention, there is disclosed a method of simultaneously shielding, anchoring, and containing an object in the event of gale-force winds. Such method comprises the steps of:

1 casting an oversize, substantially wind-permeable flexible net means over said object so as to substantially cover the top of the object; and

2 attaching the wind-permeable net means proximate an outer peripheral edge thereof to ground ***anchor*** means, so that the net extends downwardly and outwardly from the top at an acute angle to each of the sides of the object, so as to surround at least a substantial portion of each of the sides with an inclined, wind-permeable surface.

In a preferred embodiment, the apparatus of the present invention further comprises the combination of:

1 an oversize wind-permeable perforate sheet means of a surface area substantially greater than the combined surface area of a roof and outer side walls of a trailer home over which it is adapted to be placed, wherein such sheet means is extendable downwardly and outwardly from the roof at an acute angle .alpha. to the outer side of the walls of the mobile home;

2 a plurality of ground ***anchor*** means adapted for placement in the ground surrounding said home; and

3 attachment means, attachable to the periphery of the perforate sheet means, to allow the perforate sheet means to be secured to the ground ***anchor*** means.

In a further preferred embodiment of the present invention, there is disclosed a method of simultaneously shielding, anchoring, and containing a trailer home or motor home in the event of gale-force winds. Such method comprises the steps of:

1 casting an oversize, substantially wind-permeable flexible net means over a mobile home so as to substantially cover the roof of the home; and

2 attaching the wind-permeable net means proximate an outer peripheral edge thereof to ground ***anchor*** means, so that the net means extends downwardly and outwardly from the roof at an acute angle .alpha. to each of outer side walls of the trailer home, so as to surround at least a substantial portion of each of the outer side walls with an inclined, wind-permeable surface.

Surprisingly, I have found that by providing a net formed of a resiliently flexible material, such as a flexible thermoplastics material, sufficiently taut around the object as to give the net one or more flat stationary planes, acutely angled to the object, that windborne debris can be restrained and deflected from the object to prevent damage thereto. I have found that when such debris hits the net with appreciable force, the net is temporarily deformed at an area of at least one of these flat, stationary planes under the impact of the flying debris. The resilient net material absorbs the energy of impact and surprisingly, this energy is distributed throughout the net adjacent the impact site and transferred to the restraining ***anchor*** means. The extent of this impact energy distribution throughout the net to the anchors allows of the unexpectedly high degree of efficacy of the net in restraining and deflecting the debris.

Thus, the invention provides a combination and method as hereinabove defined wherein a side or face of the net is so formed as to be deformable from its stationary plane and so biased as to deflect or restrain windborne flying debris by absorbing impact energy by distribution thereof through said material.

The net is, thus, so formed and taut as to constitute resiliently flexible deflection means to deflect and restrain flying debris.

While it is desirable to have the net fully covering the object to be protected, for example, in the case of a building, trailer or mobile home, the roof and sides, the invention is applicable to those situations where only one or more sides need to be protected. One edge of the sheet may be attached to only one side of a structure to protect a window or the like, with the opposite edge being secured to the adjacent ground or surface at a distance from the base of the structure. Also within the scope of the present invention are those embodiments wherein the net is spaced away from, but adjacent an upper part of the object, structure and the like, to be protected. The net may be directly or indirectly supported on or by a frame so

spaced away from the object but to be effective in providing the desired protection from windborne debris. Such arrangements in this specification and claims are embraced by the terms "adapted for placement around said object" and "adapted for placement over the roof" and the like.

Thus, the system of the invention in one aspect has the net fully covering the top of the object, for example the roof of a trailer home. This provides a means of restraining and containing the home and any contents contained therein should the sides of the home be penetrated to allow air pressure build up within the home. In an alternative embodiment, the home may be contained and restrained by the system notwithstanding the net does not fully cover the top or roof of the home.

The substantially wind-permeable, flexible netting extends outwardly and downwardly at an acute angle from an upper part to provide a stationary substantially planar inclined sloped surface around the sides of the object and is of sufficient strength and resilience so as to effect distribution of the energy of impact between windborne debris and the netting throughout the netting and, optimally, as far as the ***anchor*** means. Such efficacious distribution of the impact energy reduces the likelihood of a breakthrough of the net to allow airborne debris to pass therethrough.

Preferred flexible materials are resiliently flexible thermoplastics such as the polyolefins, polyesters and polyamides. Preferred polyolefins are polymers and copolymers of the ethylene, propylene and polybutadiene families with for example other olefins and vinyl acetate. As examples, high density, low density and linear low density polyethylenes and 1,2-polybutadienes may be mentioned. The term "polyethylene" includes ethylene homopolymers, and copolymers of, such as for example vinyl acetate, acrylic acid, methyl methacrylate, butene, n-hexene, 4-methyl-1-pentene and octene polymers with ethylene and blends thereof. Most preferred polyethylenes have oriented molecular structures, such as gel spun oriented polyethylenes sold under the trade marks of SPECTRA, DYNEEMA, MIKELOW. A preferred polyester is polyethylene terephthalate. By the term "nylon" as used in this specification is meant melt-processable thermoplastic polyamides whose chain structure features repeating amide groups, such as, for example, amorphous nylon, nylon-6, 6 (polyhexamethylene adipamide), nylons-6,9,-6,10 and -6,12, nylon 6 (polycapromide), nylon 11, nylon 12, polymers, copolymers and blends thereof. A preferred polyamide material is Nylon 6,6 copolymer of 1,6-diaminohexene and adipic acid.

I have found that one of the benefits of the protective net system of the invention is a reduction in wind pressure on the windward surface of the object protected by the net, due to reduced passage of wind through the net.

I have found that when preferred nets of use in the invention were tested to failure by the impact on the net of either a heavy test weight in a drop test or by a projectile fired from an air cannon to effect breakthrough, that the resulting hole caused by the impact was so localized that the efficacy of the net in continuing to provide a protective membrane around an object was not substantially affected. A protective system capable of such continued efficacy is most valuable. This should be contrasted with systems formed of non-resiliently flexible materials such as tempered and heat strengthened glass, wood, such as plywood, chipboard and the like, aluminum sheeting and steel wire, which are most likely to break, shatter or collapse under comparable impact energies.

The mechanical characteristics of the net of use in the practice of the invention, such as mesh size, fabric denier and fabric and net construction may be readily and suitably determined from the physical characteristics of the flexible material in view of the desired efficacy.

The size of the mesh of the net not only influences the range of projectile sizes which the net will stop, but

also is a factor in the capability to absorb the energy of an impact. Smaller mesh sizes allow objects to strike more net elements, which better dissipates the impact energy. In order to withstand a given impact, a net with larger mesh size has to weigh more than a net with smaller mesh size.

The net of a typical 4 m.times.4 m dimension, preferably, should be able to withstand an impact energy of at least 400 Joules, more preferably more than 500 Joules and most preferably at least 800 Joules.

Table 1 shows the energy to break (MJ/m.sup.3) values for several thermoplastic fibres of use in the practice of the invention.

The area under the curve of a graph of tensile strength (MPa) plotted against elongation L/L is a rough measure of the energy to break the fibre i.e. the breaking energy per unit volume of fiber material. These values have been divided by the density of the fiber to obtain the equivalent specific fracture energies in J/g.

TABLE 1

Fibre	Tensile Strength (MPa) A	Elongation to Break (.DELTA.L/L) B	Energy to Break AB/2 (MJ/M.sup.2)
Nylon 66	300-960	0.16-0.66	75-100
Nylon 6	400-910	0.16-0.5	73-100
Polyethylene Terephihalate (PET)	270-1160	0.12-0.55	70-75
Polypropylene	240-640	0.14-0.8	45-95
Polyethylene	290-590	0.1-0.45	30-65
Kevlar (Dupont)	2760	0.03	42
E-Glass	2100-4500	0.03-0.05	55-70

The following explanation is given by way of guidance in determining the configuration of the thermoplastics material constituting the net.

The specific energies of most synthetic fibres are approximately 50-100 Joules/gram. In the case of, for example, a 4.09 kg projectile impacting at 15 meters/second, a kinetic energy of impact of approximately 460 Joules is imparted to the net. A net having a mass and configuration resulting in a distribution of 0.033 g/cm.sup.2 thermoplastics material will thus require about 3.3 Joules/cm.sup.2 to effect breakage. For a projectile impacting on an area of 34 cm.sup.2 the net will withstand a load of up to 112.2 Joules.

The force on the impact area will be distributed over the entire area of the net such that the stress will decay outwardly from the area of impact wherein approximately half the impact energy will be dissipated outside the periphery of the contact zone. Some energy may be converted to heat by plastic flow and friction.

Thus, a heavy object, travelling at a high velocity and impacting a small area will exceed the breaking energy, eg. a steel rod impacting at one end. A solid spherical rock (density 2.8 g/cm.sup.3, a diameter of about 10 cm) travelling at 15 m/s would impart about 165 kJ to the net. About half of this energy 82.5 J is concentrated on an area of 78.5 cm.sup.2, with the remainder being largely dissipated over the entire structure.

However, the net will support more than 240 J for an area of 78.5 cm.sup.2 assuming a net fabric weight of 0.033 g/cm.sup.2. This is a worst case scenario which assumes all energy is transmitted to this small area of the net. In practice, some of the energy is spread out over the whole net and to the anchors. This example suggests that stones, even large ones, cannot penetrate the net at 15 m/s but might penetrate at velocities above 24 m/s for a fabric having an areal weight of 0.033 g/cm.sup.2. Thus, the weight/unit area of the fabric net determines the resistance to penetration. Since stones/masonry are the most likely source of damage, a 0.066 g/cm.sup.2 fabric should prevent penetration at a velocity of 30 m/s.

Table 2 below gives the approximate minimum weight/unit area of a plastics net material derived to prevent breakthrough at the given velocities for a spherical object weighing 4.09 kg and having a density of 2.89 g/cm.sup.2. The specific energy to break of 100 J/g of the fibre is assumed to be a reasonable average for synthetic fibres.

TABLE 2

Impact Rating of Net for a Spherical Object (mass: 4.09 kg; density 2.8 g/cm.sup.3)

Velocity m.p.h.	m/s	Kinetic Energy of 4.09 kg object (Joules)	Weight of Net, kg/m.sup.2
50	22	990	0.7
60	27	1490	1.0
70	31	1965	1.3
100	45	4141	2.6
120	54	5963	3.8
150	67	9180	5.9

The net may optionally be formed, for example, of an extruded, woven or non-woven, knotted, knitted, crocheted or braided, knotless web. Preferred configurations are those known as a raschel crocheted knit or as a lockstitch configuration.

A woven i.e. interlocked perpendicular threads configuration is less preferred in the practice of the invention. Intersections can easily slip to allow relatively large holes to be formed without actual breakage of any fibres.

In extruded netting, net elements are solid strands of material, instead of assemblages of fibres having solid intersections. Extruded netting can be very cheap, but strength is low due to the lack of the alignment of molecules and stiffness may be quite high.

Knotted netting is efficacious but is less preferred and is generally formed with pre-assembled cord. However, preferred small mesh sizes are generally impractical to manufacture, and strength is lost in the knots. Thus, use of such a configuration requires a heavier net with reduced ability to stop small debris.

Braided netting, where yarns cross each other in a regular pattern, allows for high strength and a high degree of stretch. Intersections can be knotless (e.g. Ultra Cross configuration), giving no reduction in strength. Intersections allow some limited slip, which may allow failure to a limited degree to propagate from one element to another.

One edge of net arrangement of use in the invention consists of reinforcement with either 5 cm wide nylon, polyester or polypropylene webbing folded over the edge of the net and stitched on, typically with two rows of stitches, to leave a 2.54 cm strip of webbing along the edge. The net may itself be reinforced at the edge by increasing the amount of material used in the raschel knit. This is a straightforward procedure with raschel machines. Rings are attached to the edging using 2.54 cm webbing, and straps are used to attach these rings to a peripheral cable, which is in turn attached to ground anchors.

Further objects and advantages of this invention will appear from the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be better understood, preferred embodiments will now be described by way of example only with reference to the accompanying drawings, wherein:

FIG. 1 is a perspective view of the apparatus of the present invention, in its intended-use position to shield, ***anchor,*** and contain a trailer home in gale-force winds;

FIG. 2 is a plan view of the apparatus of the present invention, in the direction of arrow "A" in FIG. 1;

FIG. 3 is a section view of the apparatus of the present invention, taken along plane B--B of FIG. 2;

FIG. 4 is an enlarged cross-sectional view of the attachment means and ***anchor*** means of the present invention shown in FIG. 3;

FIG. 5 is a view of an arrow `c` of FIG. 4;

FIG. 6 is a perspective view of another embodiment of the apparatus of the present invention, in its intended-use position to shield, ***anchor,*** and contain a trailer home in gale-force winds; and

FIG. 7 is an enlarged view on the area designated as `F` in FIGS. 1 and 6 showing coupling means for joining sections of perforate sheet together.

FIG. 8 is a plan view of an alternative apparatus of the invention;

FIG. 9 is a sectional view of an alternative embodiment of the invention showing an alternative net deployment system;

FIG. 10 is a sectional view of an alternative embodiment of the invention showing a further alternative net deployment system;

FIG. 11 is a sectional view of an alternative embodiment of the invention showing a still further alternative net deployment system; and wherein the same numerals denote like parts throughout the

drawings.

FIG. 12 is an illustration of a net useful in the present invention; and

FIG. 13 is an enlarged view of an intersection of the net of FIG. 12.

DETAILED DESCRIPTION OF THE INVENTION

FIGS. 1 and 6 show a perspective view of two different embodiments of the apparatus 10 and method of the present invention for securing trailer homes and motor homes 12 (hereinafter mobile homes) against gale-force winds.

An oversized, substantially wind-permeable perforate sheet means 14, capable of being cast or placed over the roof 16 of a mobile home 12, is contemplated as an essential component of the apparatus 10 of the present invention. In the preferred embodiment, the perforate sheet means 14 is a flexible woven net, preferable formed of a water-resistant braided polyethylene.

The surface area of the sheet means or net 14 of the present invention is greater than the combined surface area of the roof 16 and side walls 18 of the trailer home 12. This excess size is important, since a necessary requirement of the invention is that net 14 when placed over the roof 16 of the mobile home be adapted to extend downwardly and also outwardly from the roof 16 at an acute angle .alpha. to the outer side wails 18 of the mobile home so as to create a protective inclined sloped surface 25 around each outer wall 18, as shown in FIGS. 1, 2 and particularly FIG. 3.

In a preferred embodiment, net 14 extends downwardly and outwardly so that the outer peripheral edge 20 thereof extends to at least the level of the lowermost portion 22 (floor) of the mobile home 12, so as to provide a protective inclined surface 25 proximate the entire surface of each outer wall 18 of the mobile home, as shown in FIG. 3.

Attachment means 24 are further provided, as shown in FIG. 1 and in greater detail in FIGS. 4 and 5, attachable to the perforate sheet means 14 proximate the outer peripheral edge 20 thereof. Such attachment means 24 allow net 14 to be attached to ground ***anchor*** members 30 located in the earth surrounding the mobile home 12 (see FIGS. 4 and 5), to thereby maintain net 14 in the angular outwardly extending position as shown in FIG. 3 around all outer sides 18 of mobile home 12. More particularly, it is desirous that the ***anchor*** means 30 be interspersed about the periphery of mobile home 12, as shown in FIGS. 1 and 2, and the dimensions of net 14 be such that net 14 is maintained at an outwardly extending angle .alpha. from the outer walls 18, as shown in FIG. 3. In a preferred embodiment angle .alpha. so formed between the net and the outer side walls is between 15.degree.-60.degree. and preferably between 20.degree.-35.degree.. Angle .alpha. should be a compromise between as high a value as possible to thereby afford as a "shock-absorbing" distance between net 14 and outer walls 18 to allow net 14 to protect walls 18 from airborne debris, while at the same time being as low a value as possible to thereby minimize the size of the net means 14 required.

Since mobile homes are generally of sizes ranging from 30 ft.-70 ft. in length, by 10 ft. in width, net 14 needs to be of a general rectangular shape of at least 30'.times.50' (1,500 sq. ft.) for the smallest trailer home size of 30'.times.8'.times.10', in order to have a protective inclined sloped surface 25 extending outwardly and angularly downwardly to protect substantially all of the outer side walls 18 of mobile home 12 to the level of the floor 22 of the trailer home. Dimensions of this size will permit an angular slope .alpha. of net 14 of up to approximately 30.degree.. Angle .alpha. should be the greatest value possible at

which net 14 will extend with its peripheral edge 20 to a position level with the floor surface 22 of the mobile home, to thereby ensure walls 18 are entirely protected from horizontally-moving airborne debris.

Mobile home sizes greater than 30'.times.8'.times.10' require nets 14 of dimensions larger than 1,500 sq.ft. if an angle .alpha. is to be maintained and if peripheral edge 20 of net 14 is to extend to a level of floor 22 to thereby protect all of the surface area of the outer walls 18 from impact damage due to airborne debris.

Notably, in order that net 14 when placed over the mobile home be adapted to extend evenly and uniformly downwardly and outwardly with a minimum of bunching and folding in a preferred embodiment the perforate sheet means is comprised of two or more irregular shaped perforate sheets or nets 14' joinable along various seams 40, as shown for example in FIGS. 1, 2 and 7. Accordingly, when a perforate sheet means 14 assembled in the preceding manner is placed over mobile home 12 and attached to the ***anchor*** means 30, a wrinkle and bunch-free sloped surface 25 is thereby formed proximate each of outer walls 18 of mobile home 12, as shown in FIGS. 1, 2 and 6.

To accomplish the joining of each of the various perforate sheets 14' which comprise entire net 14 releasable coupling means 42 may be utilized to join the perforate sheets along a seam 40 thereof, as shown in FIG. 7. These coupling means 42 may be of any type commonly known in the art, but in a preferred embodiment are a steel `D`-shaped snap-ring.

Advantageously, releasable coupling means 42 along one or more seams 40 allows entry by a person in and out of the mobile home 12 when the apparatus 10 of the present invention is assembled about the mobile home.

Notably, the force exerted by gale-force winds of up to 150-160 miles per hour, as was recently experienced in Hurricane Andrew which struck the eastern seaboard of the State of Florida and some of the other states surrounding the Gulf of Mexico, including Louisiana, in August 1992, can be quite significant.

Utilizing the formulas:

P=C.times.V.sup.2 and

F=P.times.A

where:

P is pressure in lbs. force exerted on an area,

C is a constant of ##EQU1## (assuming air at a specified density at standard temperature and pressure) V is velocity in miles per hour, and

A is the surface area,

the maximum force exerted by a wind of a given velocity against a perpendicularly-disposed outer wall 18 of a trailer home of a given area A can easily be calculated.

From Table 3, it can be seen that the force exerted by a gale-force wind of 160 miles per hour on a mobile home size of 45'.times.8' (.times.10') can exceed 24,000 pounds.

TABLE 3

Wind Speed (mph)	Pressure (lb/ft.sup.2)	Wall Size of Mobile Home (ft.sup.2)	Force (lbs)
50	6.75	280 (35' .times. 8')	1890
	6.75	360 (45' .times. 8')	2430
60	9.72	280 (35' .times. 8')	2722
	9.72	360 (45' .times. 8')	3499
70	13.23	280 (35' .times. 8')	3704
	13.23	360 (45' .times. 8')	4763
80	17.28	280 (35' .times. 8')	4838
	17.28	360 (45' .times. 8')	6221
90	21.87	280 (35' .times. 8')	6124
	21.87	360 (45' .times. 8')	7873
100	27	280 (35' .times. 8')	7560
	27	360(45' .times. 8')	9720
110	32.67	280 (35' .times. 8')	9148
	32.67	360 (45' .times. 8')	11761
120	38.88	280 (35' .times. 8')	10886
	38.88	360 (35' .times. 8')	13997

To resist a force of such magnitude applied by a 160 mile per hour wind perpendicularly contacting a wall of a mobile home, the net means 14 is affixed to suitable anchoring means 30. It is contemplated that ***anchor*** means 30 of the present invention be comprised of elongate multi-helix screwable anchors 30, which may be mechanically screwed into the ground (see FIG. 3).

A number of such ***anchor*** members 30 are commercially available. One such product is multi=helix ***anchor*** manufactured by Dixie Electrical manufacturing Company of Birmingham, Ala., under Cat. No. D-284 for a tandem 8" helix ***anchor***. According to information supplied by said company, such ***anchor*** depending on soil type and length of ***anchor,*** when inserted into the soil can resist a load of between 10,000 to 30,000 lbs. Using such information, knowing of the appropriate soil conditions, the necessary approximate spacing of such ***anchor*** means 30 around the periphery of a mobile home can be determined to secure net 14 about a mobile home 12. The anchors may be installed ahead of net deployment and constitute capped sub-ground members.

To avoid ***anchor*** means 30 protruding upwardly and creating a safety hazard, it is contemplated in a preferred embodiment that ***anchor*** means 30 be recessed below the surface of the earth, as shown in FIGS. 3, 4 and 5. To facilitate this, a recessed well 70 may be further provided to surround ***anchor*** means 30, within which a cylindrical hollow canister 50 may be placed level with the surface of the ground, as shown in FIGS. 3, 4 and 5. When ***anchor*** means 30 and apparatus 10 of the present invention is not in use, a cylindrical cover plate (not shown) may be placed over the cylindrical canister 50, to thereby conceal and hide ***anchor*** means 30 from view.

Commercial cylindrical canister devices 50 and cover plates suitable for such purposes are available. For example, Brooks Products Inc., Polyplastic Division, of Cucamonga, Calif. provides a "60 series Valve Box" which is ideally suited to this purpose.

The attachment means 24 of the present invention may simply comprise a releasable attachment mechanism, such as a snap-ring, for releasably attaching the net 14 at any point proximate the peripheral edge thereof directly to ***anchor*** means 30, as shown in FIG. 6. In a preferred embodiment, however, it is contemplated that the attachment means 24 further comprise means for tightenably securing flexible net 14 to ***anchor*** members 30.

Accordingly, it is further contemplated that attachment means 24 comprise a pair of releasably securable hooks 60, 62, one of which may be secured to ***anchor*** 30 and the other to net 14 as shown in FIGS. 4 and 5. Rollable webbing connects the two hooks 60, 62, and crankable tightening means 70 is further provided to wind the webbing 72 onto a spool 74, thereby bringing hooks 60, 62 together to thereby tighten net 14 to ***anchor*** 30, as shown in FIGS. 4 and 5. An example of such a commercially available tightening means ideally suited to this purposes is model FE 400 (P/N802) Ratchet Strap, sold by Kinedyne Corporation of North Branch, N.J., having a breaking strength of 11,000 lbs., with a 2" cranking handle, and hooks 60, 62 interposed at each end.

An extremely lightweight and water resistant high-strength fibre particulary suited for net means 14 of the present invention is a braided line netting comprised of a polyethylene homopolymer having a high modulus of elasticity and a molecular weight of over 500,000. An example of such a commercially available fibre is SPECTRA*.sup.1 manufactured by Allied Fibers, a division of Allied Signal Inc. of Petersburg, Va. In "single braid format, such fiber has a break strength of approximately 48,000 lbs., and a weight of approximately 22 lbs. per 100 ft. of rope.

*.sup.1 Trade Mark of Allied Signal Inc. for polyethylene twine and rope.

In one embodiment, two netting configurations are preferred and are commercially available. One is the Ultra Cross Spectra (a registered trademark of Allied-Signal Inc.) available from NET and the other is Raschel Nylon from Polytech. Nylon is not quite as strong as the "Spectra" fiber.

The net sold as Ultra Cross Spectra comprises four bundles of fibers to make the twine. Intersections are formed by braiding the two twines through each other. This will avoid the stress concentrations seen in knotted netting. This net is illustrated in FIG. 12 and the braid and intersection in the enlargement of FIG. 13.

FIG. 8 shows an embodiment of the invention wherein the net 16 does not fully cover the top of home 12 but has peripheral net covering strips 80 taped and sewn to transverse restraining straps 82 formed of a plastics webbing material, such as nylon. Such an arrangement provides partial roof covering which allows

protrusions such as vent pipe 84, air conditioning unit 86 and television arial to extend above the net, if so required.

FIG. 9 shows an embodiment having a pair of displacing members 90 formed of a suitable material, such as, for example, polystyrene foam or rubber blocks arranged lengthwise of the roof line to provide a means of deploying the net away from the home at its upper parts to provide less risk of impact damage to these parts should a wind-borne object hit the net with sufficient force to produce extensive permanent or transient deformation of the net.

FIG. 10 shows an alternative means of providing for the net to be deployed away from the upper reaches of the object. Angled support and deployment poles 92 are arranged around the home and engage the net so as to produce a wider angle at the upper reaches of the home between the net and the home. Poles 22 may be formed of any suitable material, such as aluminum, fibre glass or wood and each may comprise individual lengths or several smaller members suitable connectable one to another, such as by bayonet fittings, screw-in mechanism or telescopic spring loaded means.

FIG. 11 shows a further alternative means of separating the net from the home at the upper reaches thereof. A plurality of resiliently flexible poles 92 formed of, say, fibre glass, bamboo or like material are joined end to end and disposed over the home in the form of an arch. Each end of pole 92 is retained in a base plate 94. The upper curved portions of pole 92 may be fixed to the top of the roof by a suitable fixing means (not shown) or merely held under tension by the embracing net.

EXAMPLES

1. Raschel Nylon Tension Tests

In order to accurately model the impact of a projectile on the netting, data regarding the stiffness and strength of the netting was obtained. Simple static tension tests were performed, with load and strain data recorded at several points for each sample.

Sample Preparation

Specimens of nylon fibres were cut from a large section of netting. A single strand (0.25 cm diameter) of the netting was followed through a series of intersections. To avoid adverse effects on the test strand, intersection strands were cut roughly five diameters away from the intersection. All cuts were made with a soldering iron to eliminate unravelling. Typical sample lengths were 1.2 m.

To facilitate gripping of the specimen, and to ensure that failure occurred in the test section of the sample, the ends of each sample were threaded through the hollow core of a short length of 0.5 cm braided nylon rope. A clamp on the end of the rope nearest the test section, along with a knot a short distance away, eliminated the possibility of slippage of the specimen through the rope.

Experimental Procedure

The test apparatus used was a Tinius-Olsen tension/compression test rig. Samples (inside the rope) were wound around a 4 cm dia. steel pipe to avoid stress concentrations and tied off to a post. Elastic strands were attached to each sample at the end of the test section as references for strain measurements.

Typical crosshead separation rate was 20 mm/min. Deflections were manually measured at specific loads

(e.g. every 4 kg).

Maximum load supported by each sample was also recorded.

Results

A typical plot of load vs. deflection is shown in Table 4.

TABLE 4

Load (N)	Strain (no. units)
0	0
49	0.09
90	0.15
140	0.20
175	0.24
225	0.27
260	0.28
310	0.30
355	0.32
400	0.33

2. Dropped Projectile Impact Tests

(A) Large samples of netting were tested for impact absorption capability through drop tests. The sample to be tested was securely fastened to a rigid frame, and a projective of measured weight and dimensions was dropped onto the specimen from a range of measured heights.

Apparatus

The netting used was 210/20 twine, (Hafner Fabrics, Toronto, Ontario Canada), 1.27 cm length of stretched mesh 100% Nylon 6,6 (Du Pont) raschel knit configuration. The raschel knit is a knotless configuration, with strands and intersections `crocheted` together. The designation 210/20 indicates that 20 ends of 210 denier fibre form the yarn. The resulting twine was roughly 1 mm in diameter. The mesh had a breaking strength of 25 kgs. and the mesh squares were roughly 6 mm wide.

Breaking strength is an indication of the net's capabilities. Breaking strength is measured by pulling apart one square of the finished product, so the element strength is half the breaking strength. Denier is a measure of a fibre's weight. One denier is equivalent to the weight in grams of a 9000 m length of the fibre. Thus, a 9000 m length of 210 denier fibre would weigh 210 grams. Stretched mesh size indicates the distance between intersections, along two sides of a square. Thus 1.27 cm stretched mesh corresponds to roughly 0.635 cm squares.

The raschel knit construction technique consists of essentially crocheting the yarns (three yarns together at a time) and forming loops in the net elements. Intersections between elements of the net are accomplished without knots; the crochet process continues through the intersection, with one yarn being exchanged between the intersecting elements. A main advantage of the raschel knit is its ability to stretch to a large degree: as much as 50% strain-to-failure for an element.

Another advantage of raschel is that, if one element of the net is damaged, there is no tendency for adjacent intersections, or adjacent elements, to unravel. This avoids single-point failures.

A third advantage is that intersections cannot slip significantly, due to the exchange of yarns. Thus an opening cannot be stretched wider by wind or impacts.

One more advantage is that no significant strength is lost in intersections. Knotted netting configurations lose significant performance due to the stress concentrations of the knots.

A system for edge attachment was installed on each sample of netting to be tested. Earlier versions of this consisted of a rope or cable strung through the outside squares of the netting, the latter version consisted of a length of 5 cm webbing sewn onto the edge of the netting, with D-rings attached to this webbing using small 2.54 cm pieces of webbing

A rigid frame, roughly 4 m square, was constructed from 10 cm angle iron to support the test samples. 2.5 cm eye bolts were attached to the inside corners and at the centres of each side of the frame. A 0.6 cm cable was strung through the eye bolts and tightened with a turnbuckle. The netting was attached to this cable by stringing a rope between the edge attachment system and the cable every foot or so along the perimeter of the sample.

The degree to which the test specimen was stretched into place depended on the type of edge attachment--the webbing allowed for very little stretch, whereas the rope strung through the edge allowed for ample pre-stressing (approximately 13.7%).

The projectile used was a steel cylinder roughly 9 cm diameter, roughly 20 cm long, and 11.7 kg weight. As the projectile had fairly sharp edges, tape was placed around the bottom edge to avoid cutting the test specimen. A ring was attached to the top of the weight to support it from the crane.

Experimental Procedure

The hook of a crane was placed above the centre of the net. A rope was strung through the hook and attached to the projectile. A tape measure attached to the hook was used to measure the height of the projective above the net. The projectile was dropped from increasing heights until the net failed. A video camera recorded all tests, and was used to measure displacement of the net, as indicated by a scale on the far side of the frame.

Results

The maximum height from which a projectile could be dropped without damaging the net ranged from 9.3 m (for the pre-stretched sample) to 10.21 m (for the unstretched sample), which corresponds to an impact energy of 1100 to 1200 Joules. The maximum displacement of the pre-stretched sample was approximately 1.0 m whereas the maximum displacement of the unstretched sample was approximately 1.3 m. The holes left by impacts from a greater height were typically 20 cm in diameter. The force of impact was sufficient to do significant damage to the corner eyebolts. After the series of roughly 15 tests, the eyes had been forced open, leaving gaps as large as 2 cm.

The nets were tested to failure. After the first intentional failure of the netting, several subsequent drop tests were performed on the netting. Results from these tests and direct observations indicate that damage to the net was limited to the immediate vicinity of the actual hole; outside a small distance (15 cm) away

from the hole, the net performed as well as it had before being damaged.

(B) Comparative drop tests were conducted with approximately 1.25 m.times.1.25 m samples of netting formed of various materials in various notted, knitted or raschel construction. The samples were attached by webbing and D-rings to the frame as outlined under A. The same test weight iron cylinder (11.8 kg) of 9 cm diameter was dropped from various heights until the net was penetrated.

The following materials were tested.

Sample

1. White polypropylene monofilament knit netting. Mesh size 1.5.times.4 mm. Roughly 50% open. From Roxford Fordell.

2. Black polyethylene monofilament and tape simple weave shade cloth. Mesh size 2.3 mm. 60% open.

3. Orange polypropylene multifilament knotted netting. Mesh size 13/8" (stretched mesh). Roughly 80% open. Redden 210/27.

4. Black nylon multifilament raschel knit netting. Mesh size 2" (stretched mesh). Roughly 85% open. Redden 210/42.

5. White polyester (high tenacity) multifilament knit netting. Mesh size 1.5.times.3 mm. Roughly 25% open. Much more fibre in one direction. Tek-knit 2059.

6. White nylon multifilament knotted netting. 31/2" stretched mesh. Roughly 90% open. First Washington Net #18 nylon.

7. Black nylon multifilament knotted netting. 17/8" stretched mesh. Roughly 90% open. From First Washington Net.

8. White nylon multifilament raschel knit netting. 1/2" stretched mesh. Roughly 70% open. Hafner 210/20.

The results are shown in Table 5, wherein areal density means the weight per unit area of net and the maximum impact energy is the maximum impact energy without failure.

TABLE 5

Mesh Areal Densities and Impact Resistance
Impact energies stated are the maximum impact energies without net failure

Material	Areal Density lb/ft.sup.2	Areal Density	Maximum Impact Energy (J)	Maximum Impact Energy (ft-lb)	Energy Capacity (Jcm.sup.2 /g)
1	0.0212	4.34	197	131	844
2	0.00967	1.98	undetermined	undetermined	

3	0.258	52.8	429	315	1663
4	0.122	24.9	107	79	877
5	0.469	96.0	1286	946	2742
6	0.0659	13.5	71	53	1077
7	0.544	111	143	105	2629
8	0.221	45.2	643	473	2910

Note: 2 failed at the edges (weave pulled apart).

Maximum Impact Energy is the maximum kinetic energy of the projectile as it strikes the net, without failure of the net during that particular test. It is calculated by multiplying projectile mass.times.gravitational acceleration.times.height of drop. Units are kgm.sup.2 /s.sup.2 =Joules (J), or ft-lb. These data apply to this set of tests only: 11.95 kg (26.3) lb), 31/2" diameter cylindrical projectile, striking a 1.25 square test specimen.

Energy Capacity is the maximum impact energy absorbable by a particular netting sample, compensated for the density of the sample. This enables comparisons of netting configurations to be made as if all had equal areal density. Energy capacity is calculated by dividing the Maximum Impact Energy by the Areal Density. Units are Jm 2/kg (or ft-lb/(lb/fit 2)). As with Maximum Impact Energy, these data apply only to the given test conditions.

Table 5 shows that to protect a given area with a given weight of material, the decreasing order of preference of the materials is No.8, No.5, No.7. Although Specimen No.8, 210/20 raschel nylon, performed best, other materials may be superior when modified to make them better suited to the application.

Specimen 5, for example, is much stronger in having more fibres in one direction than the other. It would likely have improved performance if strength was more equal in the warp and weft directions. The directional difference in strengths led to a "tear" type of failure, rather than the usual "punch-through" failure. Also, No.7 would probably perform better with a smaller mesh size, allowing the impacter to strike more twines in the mesh.

It will be readily understood in the art that very many varieties of knits are possible and which may be considered if the material selected has the desired high degree of stretch, high strength and high initial stiffness. Alternative monofilament construction rather than multifilament offers acceptable efficacy in being cheaper to manufacture while being only 20% weaker. It will be realised that for a given areal density of fabric netting, a smaller mesh size allows of greater impact resistance.

3. Air Cannon Tests

Impact tests were performed using a standardised air-propelled wood projectile at American Test Laboratory in Pompano Beach, Fla., U.S.A., to simulate hurricane force winds-windborne debris.

Apparatus

Similar netting--Nylon 6,6 raschel knit, was used for this test as in the previous drop-tests. The edge attachment system used was a 5 cm webbing sewn around the edge of the samples, with D-rings attached with 2.54 cm webbing, spaced roughly 30 cm apart.

A bolted wooden frame of approximately 4 m square was used as part of the restraining means. 1.3 cm eye bolts were mounted through the wood at each corner of the frame and in the centres of the sides. A 0.6 cm cable was strung through the eye bolts and tightened with a turnbuckle. Rope was used to attach the D-rings to the cable. Tension in the netting was low.

The cannon used to propel the projectile consisted of an air compressor, an air reservoir with a pressure gauge, a 10 cm air line, a manually activated butterfly valve, and a 10 cm PVC tube as a barrel of the cannon. The end of the cannon was approximately 7.5 m from the flat, vertical stationary plane of net.

The projectile was a 4 kg, 5 cm.times.10 cm.times.2.4 m Southern Pine member having its front end slightly rounded. A 10 cm diameter disc was attached to the back end to provide a pressure seal for the barrel of the air cannon.

Procedure

Four tests were performed at increasing speeds: 65, 80, 90, and 100 feet per second (fps). Speed had been previously calibrated to reservoir pressure at pressures up to 80 fps, and an extrapolation was made from this data to calculate the pressure required to provide the higher speeds. The tests were recorded on videotape and also provided the displacement of the netting during impact.

Results

The net withstood the impact of the 5 cm.times.10 cm.times.2.4 m rectangular wood projective at the aforesaid selected three speeds of up to 90 fps, with net deformation from its flat stationary plane of up to 1.1 m. At 100 fps, the net failed, leaving a 33 cm.times.30 cm rectangular hole. Surprisingly, the eyebolts in each of the comers of the frame showed significant alteration in that their eyes had been pried open and the bolt shanks bent by as much as 15 degrees. This indicated that the cumulative force of impacts of the four speeds had been significantly large and had been transferred through the net material to each of the bolts. It should also be noted that the 90 fps test success indicates that the net is capable of withstanding more than three times the energy of the standard impact test of 50 fps.

Similar air cannon impact tests with the 5 cm.times.10 cm.times.2.4 m wood member conducted on 1.5 cm thick plywood and on 6 mm thick tempered and heat strengthened glass produced penetration of the plywood and breakage of the glass at 50 fps.

The degree of resiliency of the material element of the net was measured for two netting configurations: 210/20 nylon, and 18/80 polypropylene raschel. Maximum elongation for the nylon was roughly 34%, whereas the polypropylene stretched as much as 50%. Tests showed that in one test an impact energy of approximately 800 joules on the above nylon 210/20 netting was readily absorbed by the net system while providing a displacement of approximately 0.7 m. A 18/18 polypropylene net of 65% of the areal weight of nylon 210/20 also withstood the same impact of the wooden member at 20 m/s and provided a deformation of approximately 1 m.

Although the disclosure describes and illustrates preferred embodiments of the invention, it is to be understood that the invention is not limited to these particular embodiments. Many variations and modifications will now occur to those skilled in the art.

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